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THE SANTA RITA EXPERIMENTAL RANGE

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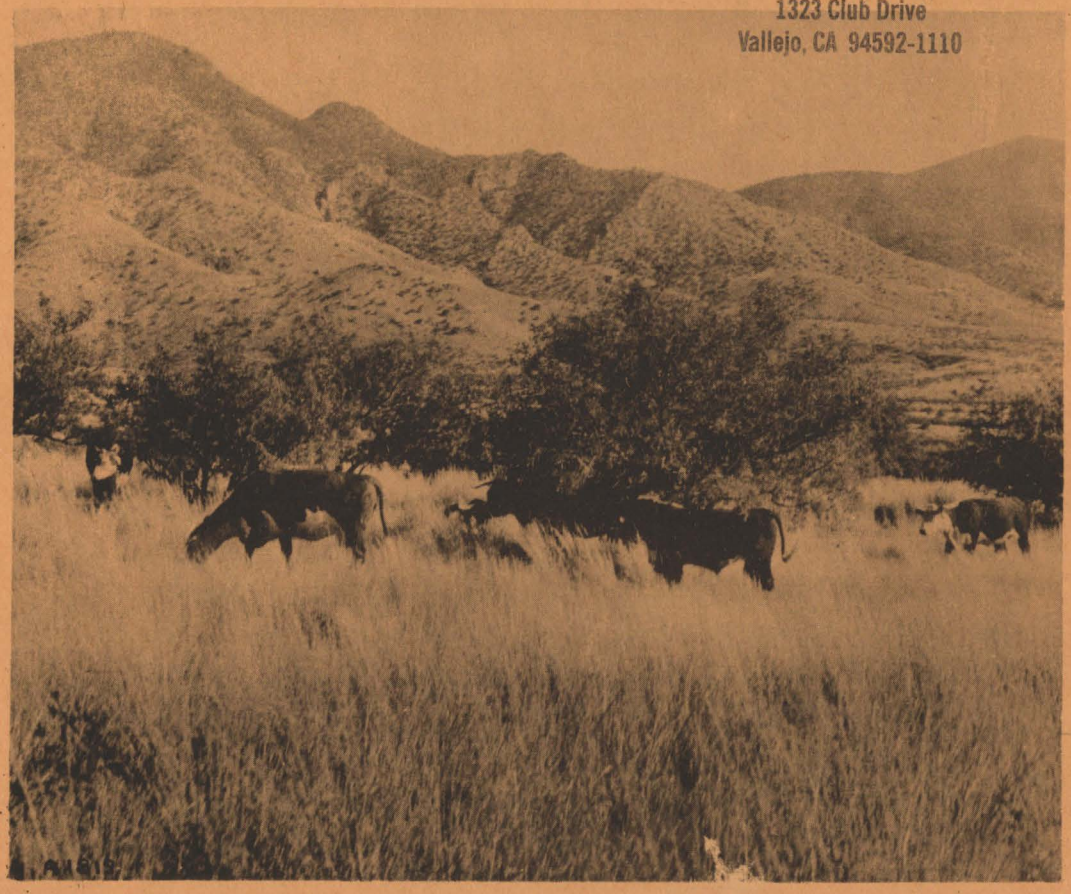

Good Range Management—Wherever It Is Practiced—
Assures Sustained Forage Production and Leads
To Better Cattle and Lasting Economic Security.

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THE SANTA RITA EXPERIMENTAL RANGE[1/]

The Santa Rita Experimental Range,[2/] established in 1903, is the oldest experimental range in the United States. It consists of 50,000 acres typical of the semidesert mixed grass and shrub range lands of the Southwest and lies along the western slopes of the Santa Rita Mountains about 35 miles south of Tucson, Arizona (fig. 1). The results of the research on the Santa Rita apply to more than 20 million acres of range land in southern Arizona, southern New Mexico, and West Texas (fig. 2).

NOT IN DB

Topography, Climate, and Vegetation

The Experimental Range slopes gently toward the northwest varying in elevation from about 4,500 feet near the mountains down to 2,900 feet along the edge of the Santa Cruz River Valley. Many shallow dry washes run through the area (fig. 3).

The climate is mild and dry. Temperatures vary from a low of around 20° F. in the winter to a maximum of about 100° F. in summer. Yearly rainfall varies from about 11 inches at the lower elevations to 18 inches at the upper with an average of about 14 inches over the Experimental Range. Precipitation in different years may vary from 65 to 180 percent of this average. Rainfall during the summer growing season averages about 7-1/2 inches, or slightly over half the yearly amount, but this, too, is highly variable.

Plant cover on the Experimental Range is classified as "desert grassland" or "mesquite-grass savanna." It consists of three major subtypes. The lower or "semidesert" type, varying in elevation from 2,900 to 3,500 feet, is essentially a shrub type with a scattering of perennial grasses occurring chiefly along the banks of the dry washes. The "mesa" type varies in elevation from 3,500 to 4,000 feet, and supports considerable shrub growth, largely mesquite, with varying amounts of perennial grasses. The "foothill"type above 4,000 feet is essentially a mixed grama grass type, but includes areas where oaks and mesquites are dominant.

1/ Acknowledgment is made to Matt J. Culley, formerly in charge of the Santa Rita Experimental Range, who prepared the original Santa Rita booklet, much of which material is contained in this booklet.

2/ A branch field unit of the Southwestern Forest and Range Experiment Station, Tucson, Arizona. At the time of its establishment, the Santa Rita Range Reserve, as it was first designated, was a unit of the Bureau of Plant Industry. In 1915 when the responsibility for Range Research was given to the Branch of Research, Forest Service, the Santa Rita Experimental Range along with other similar field units was placed under the jurisdiction of the Forest Service.

The forage is provided principally by a number of native grasses such as Rothrock grama (Bouteloua rothrocki), a slender grama (B. filiformis), sprucetop grama (B. chondrosioides), sideoats grama (B. curtipendula), black grama (B. eriopoda), hairy grama (B. hirsuta), Arizona cottontop (Trichachne californica), tanglehead (Heteropogon contortus), curlymesquite (Hilaria belangeri), threeawns (Aristida spp.), and many others of lesser importance. The common browse species on the area are velvet mesquite (Prosopis juliflora var. velutina (Woot.) Sarg.), falsemesquite (Calliandra eriophylla), range krameria (Krameria glandulosa), catclaw acacia (Acacia greggi), Wright eriogonum (Eriogonum wrighti), and baccharis (Baccharis spp.). A more detailed description of the forage plants is given in Appendix A.

Development Prior to 1915

At the time of its establishment in 1903 the forage cover of the Experimental Range was deteriorated as a result of unregulated heavy yearlong grazing over a period of years. It was immediately fenced and domestic livestock were excluded from that time until 1915.

Early observations on the Experimental Range were made by the Bureau of Plant Industry toward two major objectives: (1) to determine the period of time that would be necessary for the range to regain its productivity, and (2) to determine the grazing capacity of such a range once it had reached a satisfactory condition. As to the first objective, it was felt that the range had returned to approximately normal condition by 1912, some 9 years after it had been fenced and cattle excluded. Information on the second objective was secured largely by clipping and by mowing forage and calculating the number of animals that the yields of forage should support.

RESEARCH PROGRAM SINCE 1915

Organization and Objectives

In 1915, when the Experimental Range was placed under the jurisdiction of the Branch of Research of the Forest Service, a range research program was begun with two major objectives. First of these was to determine the best ways to manage semidesert range lands, typical of the Santa Rita, in order to improve and then maintain them at a sustained basis of productivity. The second objective dealt with methods of handling cattle on the range so as to secure the greatest annual returns over a period of time. The Santa Rita Experimental Range is not merely a demonstration of good range management, but rather a range field laboratory where research into practices that appear to promise better results are conducted and evaluated.

The administration and experimental management of the Santa Rita is unique. The lands and improvements are owned by the Federal Government. The livestock grazing the range are owned and managed by three independent operating stockmen under a cooperative agreement with the Secretary of Agriculture. The three stockmen run

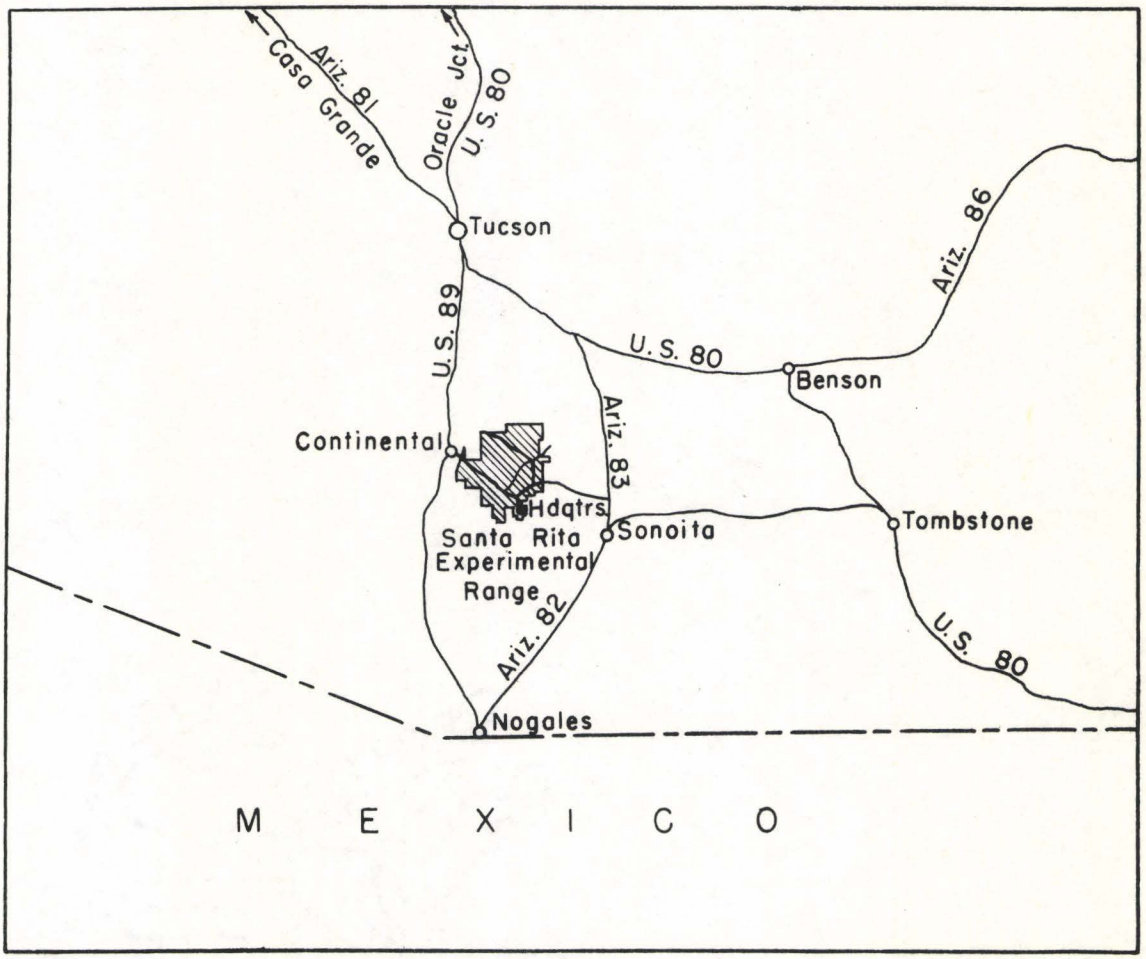
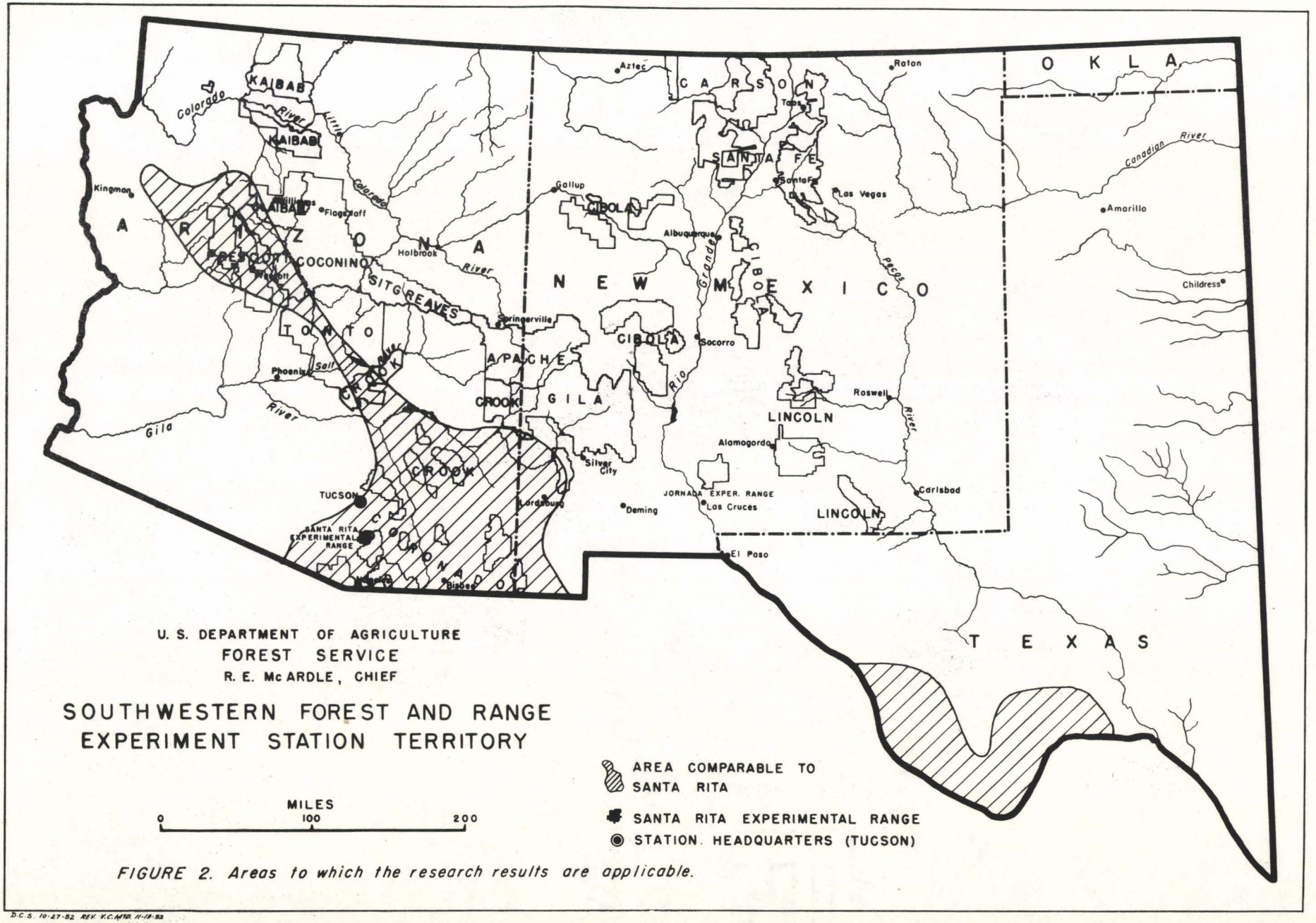


Figure 1.—The Santa Rita Experimental Range in relation to nearby cities.



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AREA COMPARABLE TO SANTA RITA

SANTA RITA EXPERIMENTAL RANGE

STATION HEADQUARTERS (TUCSON)

FIGURE 2. Areas to which the research results are applicable.

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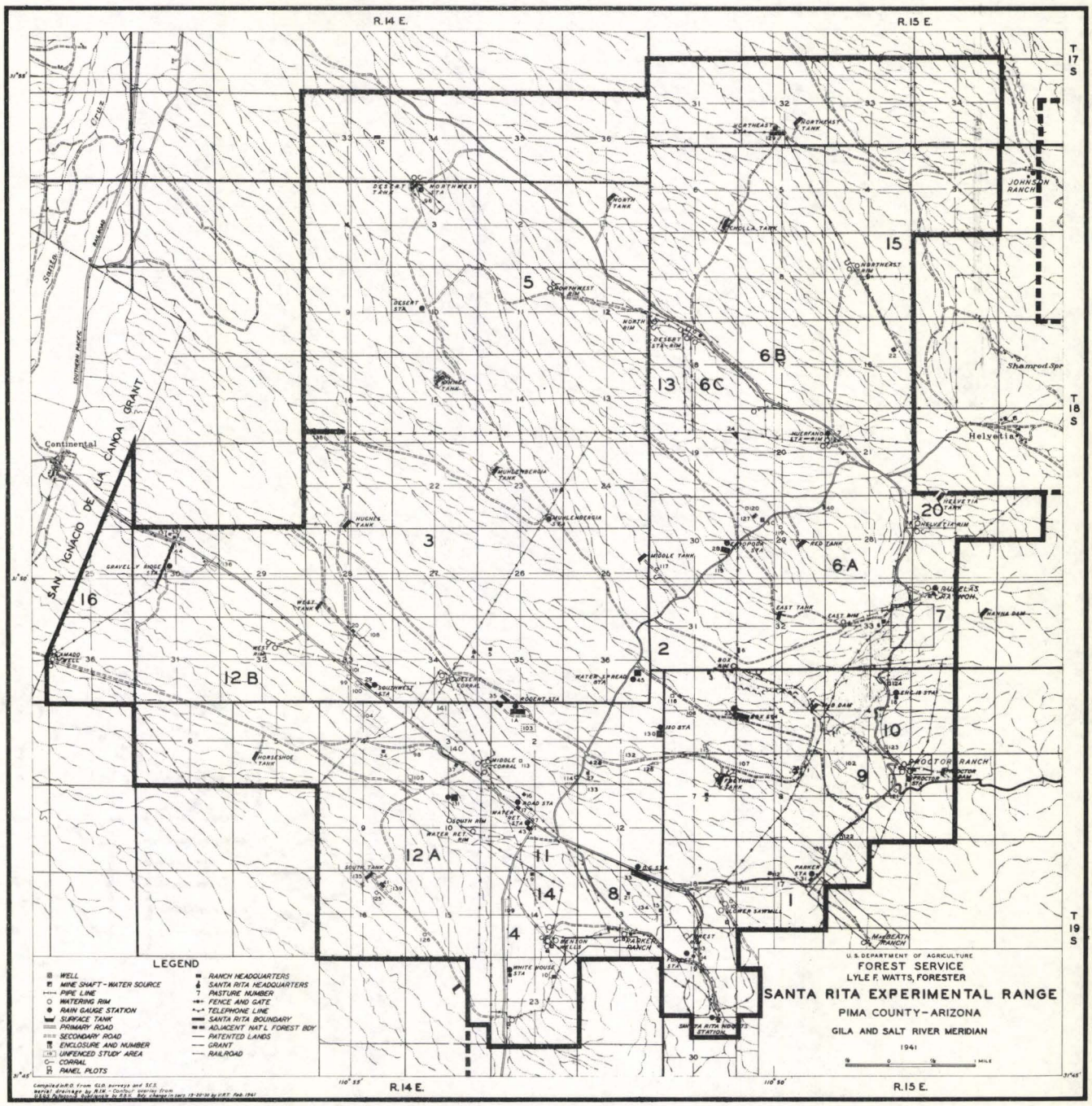
R.14 E.
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T 17 S
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SAN IGNACIO DE LA CANOA GRANT
Continental
Helvetia
Shamrod Spr
JOHNSON RANCH
PROCTOR RANCH
McBREATH RANCH
GARDNER RANCH
SANTA RITA HEADQUARTERS STATION
SOUTHERN PACIFIC
Santa Cruz River
12 B
12 A
6 A
6 B
6 C
LEGEND
WELL
MINE SHAFT - WATER SOURCE
PIPE LINE
WATERING RIM
RAIN GAUGE STATION
SURFACE TANK
PRIMARY ROAD
SECONDARY ROAD
ENCLOSURE AND NUMBER
UNFENCED STUDY AREA
CORRAL
PANEL PLOTS
RANCH HEADQUARTERS
SANTA RITA HEADQUARTERS
PASTURE NUMBER
FENCE AND GATE
TELEPHONE LINE
SANTA RITA BOUNDARY
ADJACENT NAT'L FOREST BDY
PATENTED LANDS
GRANT
RAILROAD
U.S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE
LYLE F. WATTS, FORESTER
SANTA RITA EXPERIMENTAL RANGE
PIMA COUNTY - ARIZONA
GILA AND SALT RIVER MERIDIAN
1941
1 MILE
110° 55'
110° 50'
31° 45'

Figure 3.

their herds yearlong on separate portions of the range according to a plan of management which specifies the numbers of livestock to be placed in each of the pastures. Thus an opportunity for comparisons of various degrees and systems of use is provided. The fact that the range is grazed by operating cattlemen makes the results obtained directly applicable to range practice.

Major Research Projects

Grazing Management

Grazing management research at the Santa Rita has included the following: (1) determination of what constitutes the forage crop, (2) the variations in yield of forage from year to year, (3) relative importance of rain at different seasons of the year, (4) maintenance of stand and forage yield, (5) the degree of use that native forage plants can stand, (6) the grazing capacity of the various range types, (7) possibilities of improving depleted areas through natural revegetation, (8) the grazing habits of range cattle, (9) the effectiveness of salt as a means of controlling cattle distribution on the range, (10) watering places necessary to secure the best use of the range, (11) seasonal deferred grazing, and (12) a plan of management to minimize or eliminate loss of livestock or damage to the range due to periodic prolonged drought.

Studies of handling cattle on the range have included such phases as: (1) ways in which the annual calf crop might be increased, (2) ways to improve the quality and quantity of beef produced, (3) reduction of livestock losses, (4) marketing practices, (5) improved methods of handling range livestock, and (6) the economics of range livestock production.

In addition to the study of the effects of management on practical economic grazing units, the facilities at the Santa Rita provide for intensive studies of the climate, soils, growth of the vegetation and its use by cattle and rodents, and the interrelation of these factors with one another. Cooperation is maintained with several Federal and State agencies to facilitate studies in fields related to range research. Thus a balanced program of research that permits the development of fundamental knowledge as well as the application of these findings to the range livestock industry in the semidesert range type is made possible.

Noxious Plant Control

Another phase of range research which has received increased emphasis on the Santa Rita Experimental Range during recent years is the problem of controlling various noxious plants. Several worthless shrubs, although native to the Southwest, have increased tremendously since the turn of the century, as is evident from photographs and other records of vegetation. Among the most important are velvet mesquite, cholla cactus (Opuntia spp.), burroweed (Aplopappus

tenuisectus), and snakeweed (Gutierrezia sarothrae). With the increase in these shrubby plants, forage and beef production is reduced, soil erosion is increased, and handling of livestock is made more difficult.

Artificial Range Reseeding

Reseeding to desirable forage plants is needed where native vegetation has been too seriously depleted to recuperate in a reasonable time. To fill this need, research is being done to provide the answer to: (1) what to plant, (2) how to plant, (3) where to plant, all with a reasonable assurance of success. Information is also being sought on methods by which reseeded stands can be best grazed and maintained. Answers to these questions hold the key to greatly improved range conditions on many acres in the Southwest.

SOME RESEARCH FINDINGS

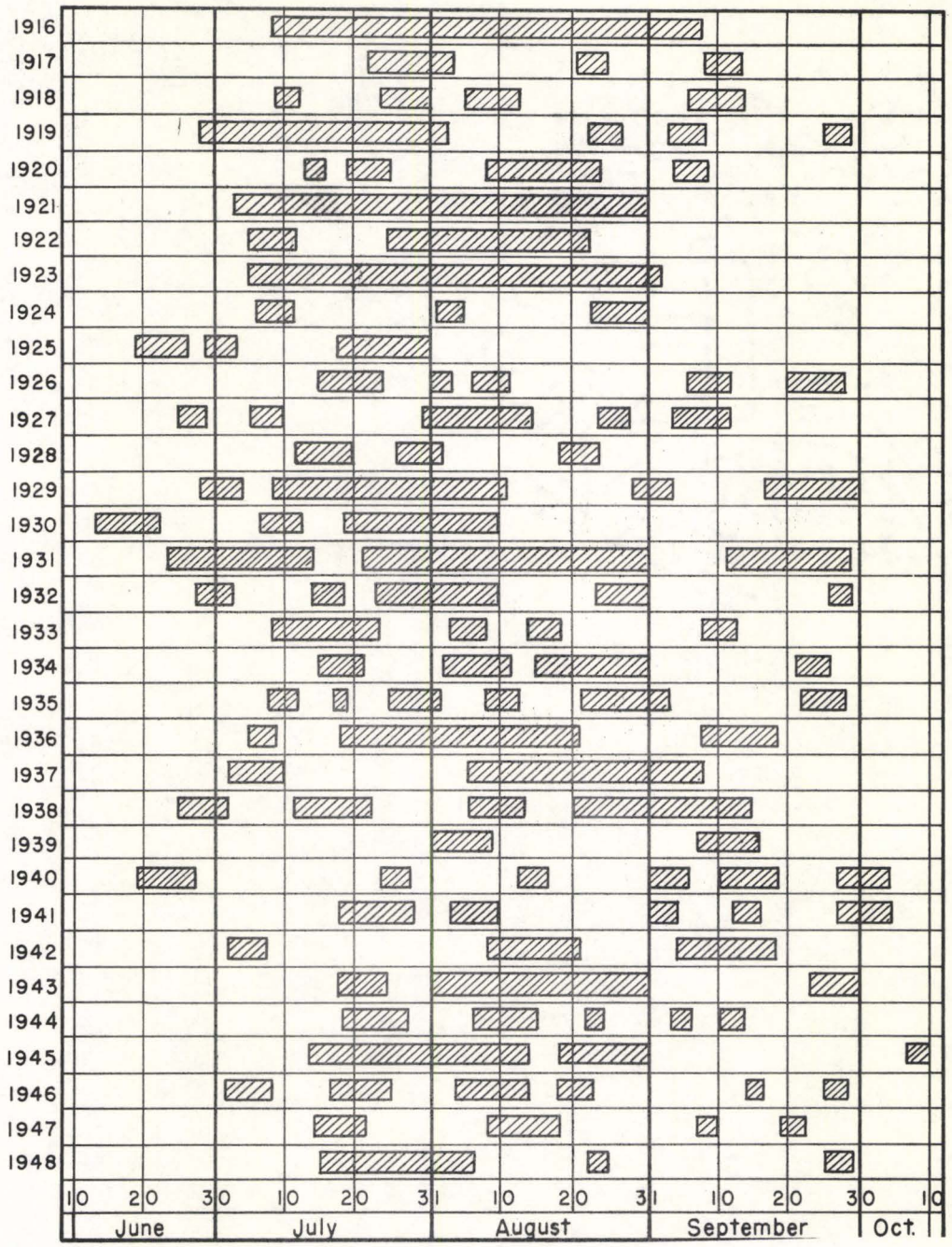
Following is a resume of some of the findings obtained on the Santa Rita as they relate to the forage crop, use of the forage crop, costs and returns of range livestock production, modern ranching methods, good range management practices, noxious plant control, and range reseeding.

Production, Management, and Returns

Forage Production

Grass makes the forage.--The forage crop produced by the native range vegetation each year is of prime interest to range cattlemen. What it consists of, when it is produced, how it varies from year to year, and what practices can be followed to assure a sustained supply are things that the modern stockman must know. Results on the Santa Rita have shown that the major part of each year's forage crop consists of the perennial grasses native to the region. Various browse species help to supplement the supply in the fall and late spring and may be of extreme value in the severe drought years. As a rule, annual weeds and grasses on the mixed grass type of range furnish but a small part of the year's forage supply. They cannot be counted on for forage more often than about once in every 5 or 6 years.

How grasses grow.--Studies have shown that, on the average, 93 percent of the perennial grass growth is made during the summer months, June through September. Ordinarily the late fall months and late spring months are too dry to permit grass growth. Winter temperatures are usually too low for growth even though adequate moisture may be present. These conditions may vary greatly. In addition, the amount, distribution, and occurrence of summer rainfall fluctuates widely (fig. 4). The average length of the summer active-growth period is about 5-1/2 weeks, although extremes as short as 2-1/2 weeks and as long as 11 weeks have been recorded. Growth of the forage plants may start and stop several times during the summer depending



Periods during which rains fell on successive days or were preceded or followed by storms of 0.4 inch or greater.

Figure 4.--Variability of effective rainfall and active forage growth periods during the summer growing seasons from 1916 to 1948 on the Santa Rita. Note the short periods of effective rainfall and growth in 1924 which resulted in a low yield of forage as compared to a high yield in 1931 when rainfall and growth were more or less continuous throughout the summer. Effective distribution of rainfall is as important as the amount in the production of a forage crop.

upon the distribution of the rainfall which often is as important as the total amount. For this reason, the forage crop should be judged by inspection of the range at the end of the growing season rather than merely by the amount of rain that has fallen during the summer months.

The variation that occurs in the annual yield of perennial grass forage is illustrated by the production of 130 pounds per acre in 1925 as compared to 730 pounds per acre in 1931 (fig. 5). This wide variation in forage of necessity must be reflected in the number of livestock that can be safely carried from year to year.

Use of the Forage Crop

Conservative stocking is safest.--Stocking annually on the basis of each year's forage production would necessitate a considerable variation in livestock numbers. Such a practice, although difficult for a strictly cow-calf outfit, would be more feasible where steers are included in the herd. The data in figure 5 show that a cow-calf outfit stocked at a nearly uniform rate, on the basis of the average annual forage yield, would experience a shortage of forage in approximately 4 out of 9 years.

Results on the Santa Rita indicate that stocking at a rate about 20 percent below that indicated by the average yield of forage is a safe basis of operation for a cow-calf outfit. This would provide adequate forage for all but 2 years of the 9. In such years some feeding may be necessary, but often the unused forage from previous years will be sufficient to carry the livestock without supplemental feed. Long-time records on the numbers of cattle that have grazed the various pastures and types of range suggest that a safe level of stocking in the semidesert subtype is about 6 to 8 head per section yearlong, in the mesa type about 10 to 14 head per section yearlong, and in the foothill or better grass type about 15 to 20 head per section yearlong. These stocking rates are for periods of average production including occasional drought years. In times of extended drought they should be reduced accordingly. Since the bulk of the forage is grown before marketing time in the fall, the stockman can adjust his sales each year in order that his stocking rate will be in line with the forage available.

Cattle need ample forage all year, yet during periods of severe drought, which must be expected periodically, forage production may be only a third of the long-time average. When drought strikes and supplementary feeding is temporarily resorted to, it should be started soon enough so that the cattle do not suffer undue loss of weight. When drought is severe or prolonged, so that feeding cannot be done economically or without punishing the range, there is no way out other than to reduce the livestock numbers accordingly. Some insurance against drought may be provided by reserving small pastures for use during critical periods. Such forage need not be lost in the good years since it can be utilized for extra conditioning

of selected animals. Too often, however, the operator, rather than cull his herd down to the reduced forage supply, takes a chance and holds over his salable livestock. He thereby loses, not only by overgrazing his range, but also by adversely affecting the quality and size of his animals. One principle to remember is that although good cattle may survive for a time on short rations they require ample forage year in and year out if they are to realize their full potential for growth and production.

Leave some grass ungrazed.--Leaving a part of the herbage produced on the ground each year allows the range a chance to improve in the better years and minimizes loss of grasses in poor years. Studies of the degree of grazing which the various native grasses can stand without injury have indicated that in general most of the native grama grasses can be used to within about 2 inches of the ground provided they are not kept continuously cropped to this level. Black grama, which is highly desirable and often an important species on semidesert grass ranges, should not be grazed closer than 3 inches from the ground. The coarser bunchgrass type of grasses such as sideoats grama and Arizona cottongrass appear to suffer if grazed continually to heights of less than 4 or 5 inches. A few species, such as bush muhly (Muhlenbergia porteri), do not appear able to stand use closer than to within about 6 or 8 inches of the ground. Cattle tend naturally to graze conservatively when the supply of forage is adequate. Only when cattle are forced to go back over an area day after day do they utilize the perennial grasses too closely.

Observations on the Santa Rita and other ranches in southern Arizona suggest that lightening up grazing on the range during the summer growing season or allowing portions to rest during this period every second or third year results in a greater variety of the better forage grasses as well as greater forage production.

Factors Involved in Returns

Calves are the cash crop.--Throughout most of the southwestern semidesert range country calves are the chief product marketed. Consequently, one of the first objectives is to secure as many calves as possible each year (fig. 6A).

An analysis of economic data obtained on the Santa Rita showed that a calf crop of about 55 percent is required to pay the operating expenses. The average of 85 percent that has been realized on the Santa Rita for the past 20 years leaves a substantial margin for profit. One of the most important factors in realizing this calf crop has been maintaining the breeding cows in good condition throughout the year by stocking moderately. Another factor that has helped is the division of the range into pastures carrying from 50 to 100 head of breeding cows. This permits much closer supervision and makes the culling of non-productive cows more certain. The use of good active bulls as well as the careful selection of cows for active breeding and good mothering qualities has also aided.

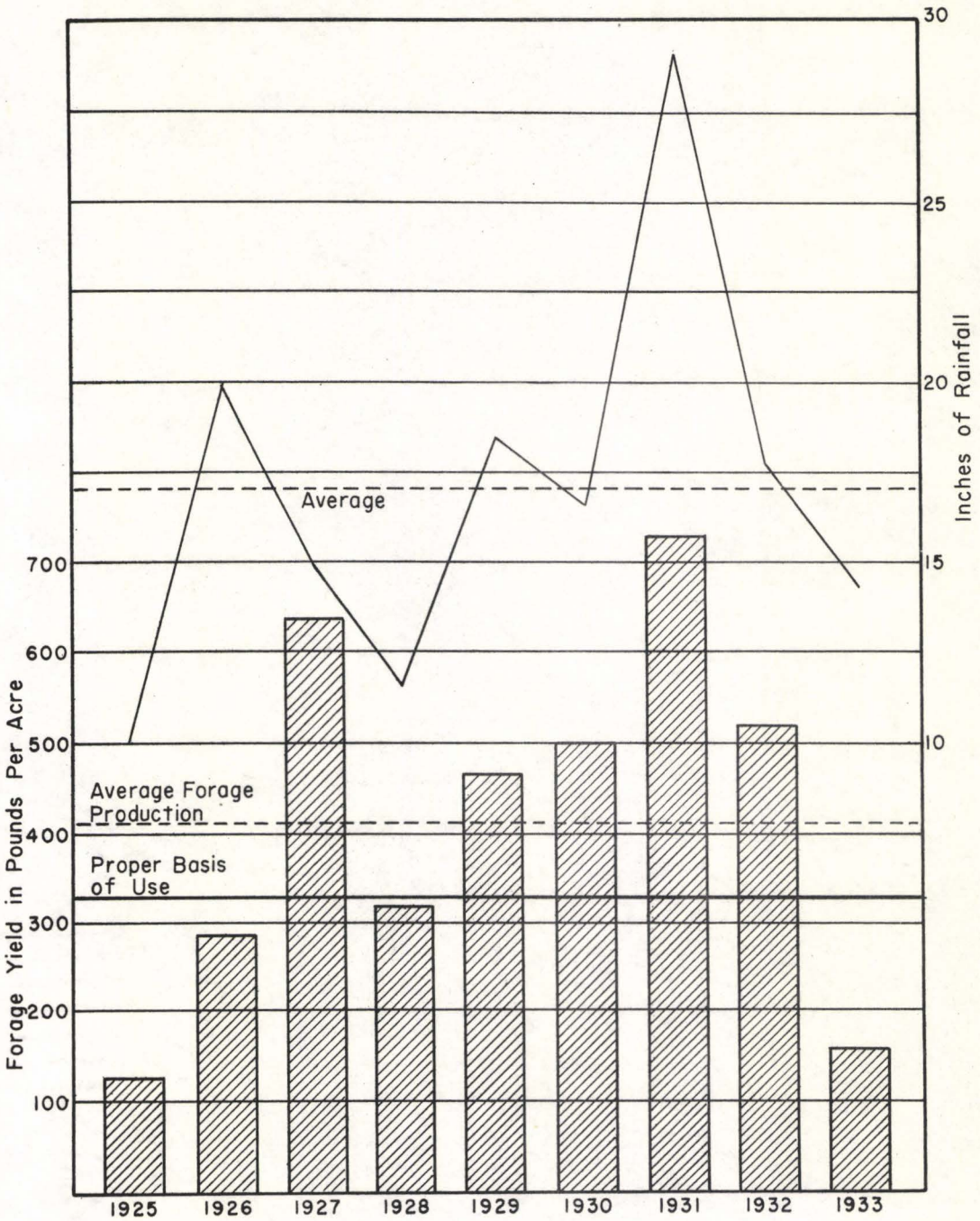


Figure 5.--The yield of forage on semidesert ranges varies greatly from year to year. Stocking the Santa Rita on the basis of the average yield would result in a serious forage deficiency in four out of the nine years. The proper basis of use for the semidesert mixed grass ranges approximately 20 percent below the average forage production and brings numbers of livestock into balance with the yield of forage in all but two years. Supplemental feeding in severe drought years may be necessary, though under good range management the carry-over of forage from the better years will generally offset this need.

Figure 6.--Good calf crops and quality cattle are essential for success. A, High calf crop percentage should be a continuing goal. B, These uniform, high quality calves reflect good breeding, ample forage, and capable management.

The size and uniformity of calves is also an important item governing the returns that can be expected (fig. 6B). A regulated breeding season has helped greatly in producing uniformity. Attention to the condition of the breeding cows during the late spring season has greatly increased the average size of calves produced. The calves on the Santa Rita now average well over 400 pounds each year and in one year averaged 470 pounds at 8 months of age.

Continual efforts to improve the grade of cattle on the Santa Rita by using only the best quality bulls and by careful selection of replacement heifers and constant culling of breeding cows have resulted in increasing weights of breeding cows from approximately 850 to well over 1,000 pounds. These larger, thriftier animals produce more and better calves and are better able to maintain production in dry years. Ample range forage has played an important part in improving the quality and size of the animals.

Death losses can be small.--Livestock losses on the range are sometimes taken as a matter of course with a feeling that there is not much that can be done to reduce them. Results on the Santa Rita have indicated that careful supervision, keeping the breeding cows in condition to properly care for their calves, and continual doctoring of sick animals along with the control of predators, can do much to reduce the annual livestock losses on the range. Santa Rita losses average less than 1-1/2 percent for all classes of livestock.

Cost keeping.--Accurate cost keeping is essential in order that an operator may know what he is making and what he is spending. The profit he has made shows in his bank account at year's end, but what was spent is gone, often for things better done without. Operating costs vary with the times, as shown by table 1. In the period 1924-34, interest on borrowed money was a large item of expense. Recognition of this encouraged paying off indebtedness, so that in a later period from 1940 to 1947 the money formerly paid out as interest on borrowed capital stayed with the operator as interest on his own equity. On the other hand labor costs in the period 1940-47 were about three times as great as during 1924-34, suggesting the operator analyze his labor needs and make the most efficient use of his labor by taking advantage of labor-saving devices or methods. A sign of the times is the fivefold increase in cost of motor car operation between the 1924-34 and the 1940-47 periods.

Comparing the average annual costs and returns for the two periods listed in table 1, it is interesting to note that while both gross returns and costs increased greatly during the second period, there was a slight increase in net returns per animal unit. However, owing to the inflated investment values the percentage of net return on the investment for the years 1940 to 1947 was only half that during 1924-34.

Table 1.--Comparison of the average annual costs and returns per breeding cow on the Santa Rita Experimental Range for the periods 1924 to 1934, and 1940 to 1947

Items	1924 to 1934	1940 to 1947
Cash Expenditures:		
Interest on borrowed money	$ 3.07	$ -
Grazing charge	1.65	2.53
Labor	2.00	(1/) 13.49
Taxes on cattle	.34	.37
Taxes on land	.05	.08
Taxes on equipment	.08	.21
Motor car operation	.41	2.03
Engine operation (pumps)	.13	.24
Freight and hauling (cattle)	.29	.20
Freight and hauling (miscellaneous)	.08	.09
Feed (largely for horses)	.16	.78
Salt	.19	.25
Vaccine	.05	.08
Inspection and weighing	.12	.09
Ranch equipment (small, movable)	.06	.04
Miscellaneous small expenses	.98	.72
Bull replacement	.91	3.00
Total cash costs	10.57	24.20
Indirect Expenses:		
Cow replacement	4.52	-
Depreciation of improvements	2.44	(2/) 6.07
Cattle losses	1.19	2.02
Total indirect costs	8.15	8.09
Interest on Operator's Capital:		
Cattle, improvements, and land	2.09	10.14
TOTAL ALL COSTS	20.81	42.43
Investment:		
Cattle	45.11	93.00
Range, improvements and headquarters	24.12	76.00
Total	69.23	169.00
Gross returns	26.44	49.29
Net returns (gross less total all cost)	5.63	6.86
Percent of net return on investment	8.1	4.1

1/Includes approximately $7.50 Manager salary.
2/Purchases only.

Livestock handling methods.--Much can be said for the old ways of doing things on the range. They were romantic, and led to a simpler and more friendly way of life. However, they cannot compete with the modern way of doing business. Cattle of earlier days were able to walk several miles to water. The higher grade, heavier cattle of today require that all parts of the range be within 1 to 1-1/2 miles of water. The old open range methods have been replaced by fenced pastures in which comparatively small numbers of cattle are grazed, making for easy and constant supervision. Such added conveniences as holding traps, corrals, squeeze and separating chutes, calf branding tables and horse trailers are all a part of the modern way of running the range cattle business (fig. 7). They not only help to cut down the labor costs and save time but are easier on the livestock, minimize injuries, and result in producing more pounds of beef. Trucking cattle to market, as opposed to driving, reduces shrinkage besides saving both labor and time. Ranchers would do well to analyze their ranch operations and employ these labor saving methods.

Noxious Plant Control

The Problem and Program

The invasion of grassland by worthless or undesirable plants has resulted in a critical problem throughout much of the Southwest. In southeastern Arizona alone, low-value shrubs occupy over 12 million acres of range land. Increases in these noxious plants on former grassland sites have been accompanied by markedly lowered grazing capacity, especially where heavy grazing use has continued. On the Santa Rita measurements show that removal of mesquite on grassland sites, accompanied by conservative grazing, may result in a fourfold increase in the production of perennial grass forage. The yield from such areas has been calculated to be 4,000 pounds of beef per section as compared with 1,600 pounds on mesquite infested land. In addition to the gain in increased production of grass and beef, there are other important benefits which result from the control of mesquite. Erosion which is ordinarily accelerated under well developed mesquite stands is reduced following the re-establishment of a grass cover. Cattle are more easily worked, and losses from screwworm are reduced.

Research aimed at developing more practical methods for controlling noxious plants is a prerequisite to restoring large areas of former grassland to their original economic productivity.

Empirical tests of the most promising methods for controlling mesquite, cactus, and burroweed, are being conducted on the Santa Rita (fig. 8). A considerable amount of fundamental research on the physiology and ecology of mesquite, as related to its control by chemical and mechanical methods, is also being carried on, and is furnishing valuable leads to the ultimate solution of the mesquite problem.

How mesquite spreads.--Mesquite reproduces only by seed. Young trees begin bearing seeds when 4 to 6 feet in height, and from then on seeds may be produced in great quantity. The seeds are hard-coated and may remain viable for many years. Livestock eat large numbers of mature seed pods, and, since many of the seeds pass through the digestive tract in a viable condition, are probably the most important single factor in spreading mesquite from infested to uninfested areas.

The Merriam kangaroo rat, which buries seeds in caches, is a significant factor in spreading mesquite on some areas. In addition, surface runoff water transports, scarifies, and plants some mesquite seeds.

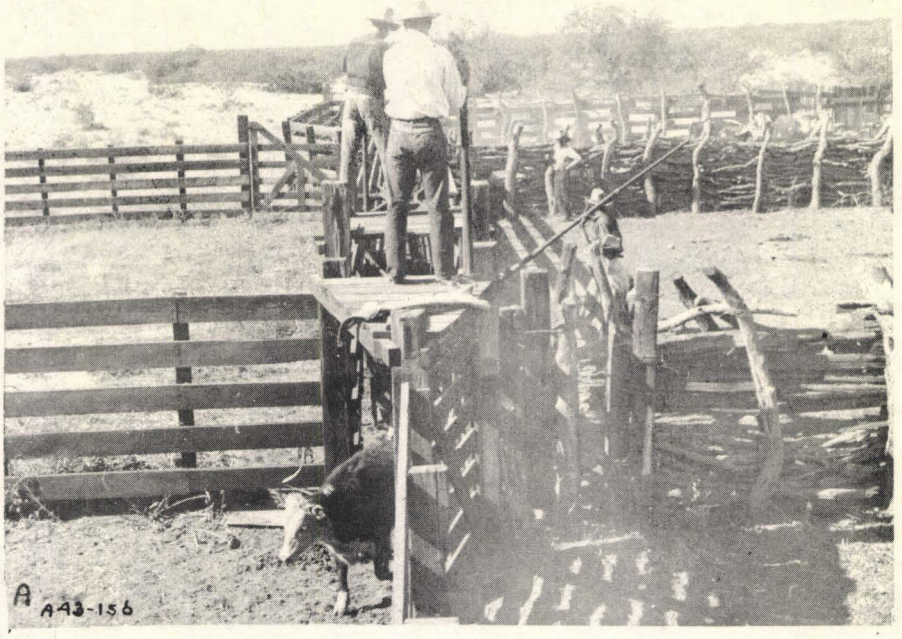
Germination of mesquite seeds occurs mainly during the summer rainy period. Tops of the seedlings develop slowly, and early growth centers mainly about development of a tap root. Few lateral roots are developed until the second and third growing season, after which time successful establishment is almost assured. Studies show that in a dense native grass cover competition by the fibrous-rooted grasses will eliminate most seedlings before they complete their first year.

Methods of controlling mesquite and other noxious plants.--Hand grubbing of young mesquites as soon as they are large enough to be noticed is recommended. This is the most effective and cheapest method for controlling mesquite in the early stages of invasion. Mechanical clearing of mesquite with heavy equipment including bulldozers, "stingers," and root cutters is effective; however, the cost may run as high as $15 per acre. A more spectacular and less expensive method involves the pulling of a 400-foot length of heavy cable or anchor chain between two large crawler-type tractors. Trees not completely uprooted by chaining or cabling must be removed individually for satisfactory results.

Diesel oil applied to the base of mesquite stems at an average rate of 1 pint per tree will kill 80 to 90 percent of the trees. With this method the oil must be applied entirely around the trunk and must penetrate downward below the lowest buds--usually 6 to 8 inches (fig. 8B). Best results were obtained from treatment during the period October through March. This method costs approximately 4-1/2 cents per tree and is recommended for scattered stands.

More extensive control methods are needed for the large areas supporting heavy mesquite stands and the possibility of controlling mesquite by airplane application of 2,4,5-T and similar selective foliage sprays is being investigated (fig. 9). While this method cannot yet be recommended for an action program, results are encouraging.

For chemical control of burroweed, the application of 1 pound per acre (Acid Equiv.) of 2,4-D ester in 5 gallons of a 1:4 diesel



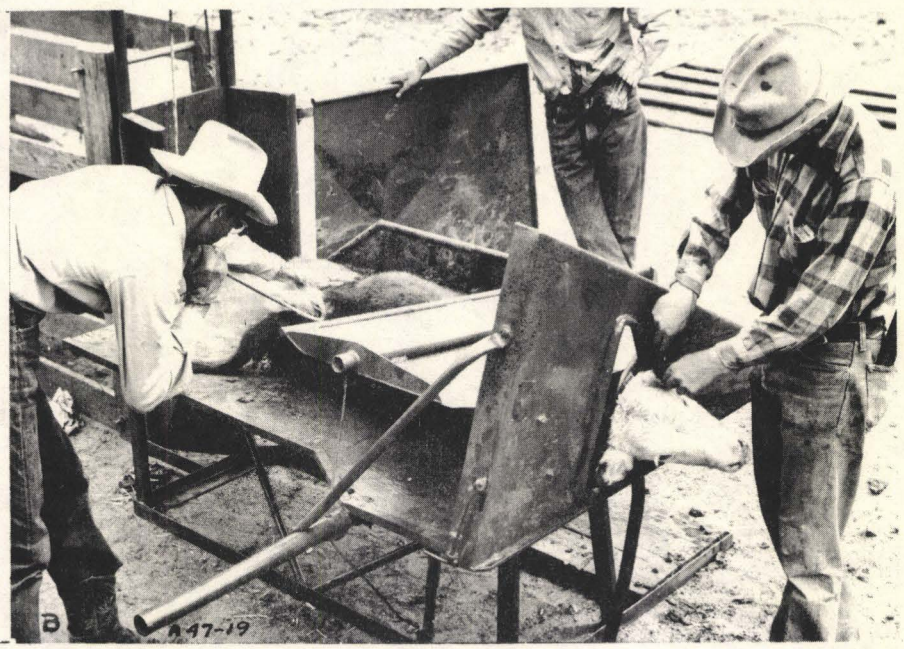
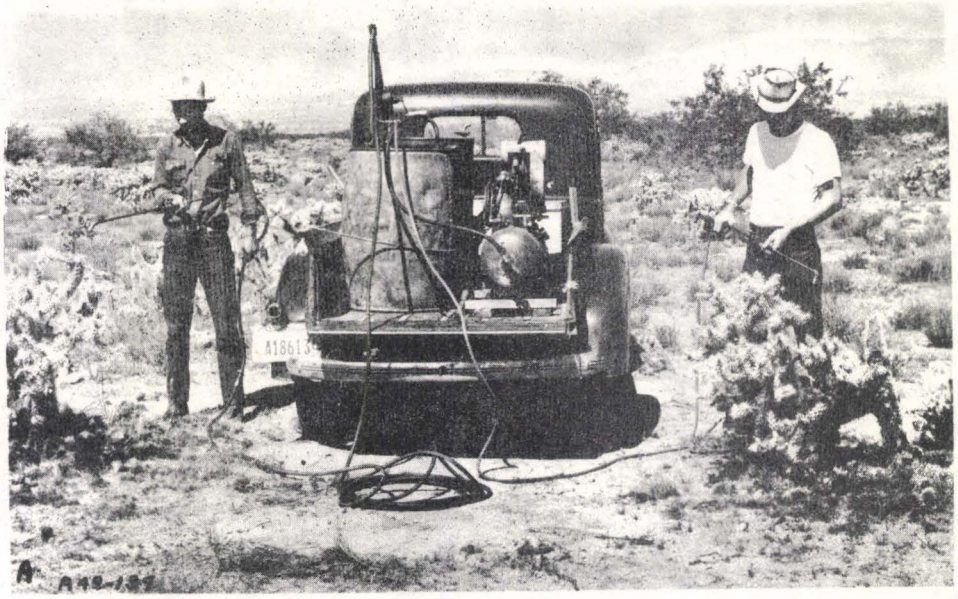


Figure 7.--Modern handling methods save labor, time, and livestock. A, Separating chutes are faster, save labor, and are easier on the cattle--reducing shrinkage--and thus adding many pounds of beef to the total that is marketed each year. B, Calf branding chutes save labor, require less skilled help, prevent injuries, and are easier on the calves and cows than the old method of roping out of a herd.



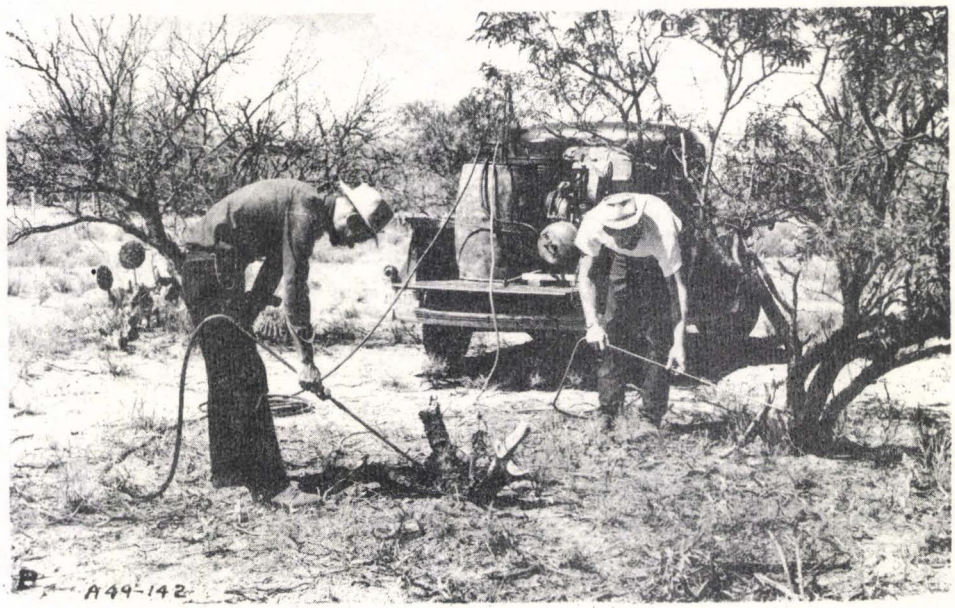


Figure 8.--Research is developing methods for the control of noxious plants on the range. A, Many chemical sprays are being tried out for the control of cacti. A small air compressor and 50 gallon supply drum can easily be mounted in the bed of a pickup. Pressures of 20 to 25 pounds are necessary for effectively spraying the entire plant. One or more hose equipped with extension spray tips can be connected to the supply barrel. B, Diesel oil--properly applied--has proven the most effective method for controlling mesquite on the Santa Rita. It can be applied to standing trees as well as stumps. The tree in the left background was killed with diesel oil. Proper application means seeing that the oil soaks entirely around the base of the trunk or stump to a depth below the bud zone.

Figure 9.--Airplane spraying is being tested. A, Spray plane applying 3/4-lb/acre 2,4,5-T on velvet mesquite on one of a series of 5-acre test plots on the Santa Rita Experimental Range. B, Appearance of mesquite on test plot 11 months after airplane spraying with 2,4,5-T. A high degree of defoliation and top kill has been obtained and about 20 percent of the trees are completely dead.

oil-water emulsion has proven sufficiently effective to warrant its use on a trial basis. On areas where practical, mowing or burning during the late spring dry period is effective in controlling burroweed. Cholla and pricklypear cactus can be killed by thoroughly wetting the plant with sprays of 2,4-D and 2,4,5-T but the high concentration and volume of spray solution required limit the use of this method to small localized areas (fig. 8A).

Artificial Range Reseeding

Objectives

Heavy grazing, prolonged drought, and the spread of noxious plants, or a combination of all of these factors have depleted the grass cover on considerable areas of range lands in the Southwest. Restoration of certain of these sites within a reasonable length of time depends on developing practical and economical methods for range reseeding. Reseeding research on the Santa Rita includes four lines of attack: (1) evaluating factors of the site which determine success or failure, (2) testing native and introduced species which because of ease of establishment, seeding and growth habits, and persistence, are adaptable to range reseeding; (3) developing practical and economical methods for preparing the site, and planting the seed at desirable depths and optimum rates; and (4) evaluating reseeded stands of individual species for grazing. The following recommendations are applicable on semidesert lands in southern Arizona.

Site selection important.--Reseeding should be confined to sites where there is a good probability of success. Soils should have a loamy texture, although they may contain portions of sand or clay. Heavy or light textured soils should be avoided. Annual rainfall should exceed 12 inches. If 10 to 20 percent of the original stand of native grasses is present, reseeding is unnecessary, and proper management, noxious plant control, or both can achieve the desired improvement. If there are more than 25 mesquite trees per acre, they should be killed prior to seeding. Areas dominated by cactus should be avoided unless provisions are made for its removal, as scattering of the joints spreads this undesirable plant. Burroweed in light stands does not offer serious competition to reseeded grasses, but on sites which support moderate to heavy stands it should be reduced by spraying or mowing for best reseeding results.

Most promising species.--Lovegrasses introduced from South Africa have been most widely tested, and to date have been most consistently successful for reseeding semidesert grasslands. In ease of establishment, Lehmann lovegrass (*Eragrostis lehmanniana*) is best, followed by Wilman lovegrass (*E. superba*), and then Boer lovegrass (*E. chloromelas*). In terms of drought resistance the order is reversed. Cold tolerance is as follows: Wilman lovegrass plus 15° F., Lehmann lovegrass plus 5° F., and Boer lovegrass minus 5° F. Lehmann lovegrass is recommended for ranges comparable to the Santa Rita. Under slightly different growing conditions, one of the other species

may be better adapted. Successful stands of Lehmann and Boer lovegrass can be established at a seeding rate of 1 pound per acre; whereas 4 to 6 pounds of Wilman's are required. In flood flats or along arroyos, blue panic (Panicum antidotale) is adapted.

Several native grasses are also showing promise for reseeding, although dependable commercial supplies of good seed have yet to be developed. Among these are black grama, tanglehead, Arizona cottongrass, plains bristlegrass (Setaria macrostachya), and slender grama.

Planting methods.--Soil preparation methods should attempt to eliminate competing vegetation and provide for retention of as much moisture in the soil as possible. Moisture conserving practices such as pitting and contour furrowing help the young plants to survive the droughty spring season. Pressing the seed of small-seeded species, such as the lovegrasses, into the soil provides sufficient coverage.

One combination of equipment which successfully meets the above planting requirements consists of a small tractor, an eccentric or cutaway pitting disk, and a cultipacker seeder (fig. 10A). This equipment makes a series of small pits in the soil surface and plants the seed on about 20 acres per day at a total cost of about $4 to $5 per acre. Soil preparation and planting are completed in one operation. The pits serve to trap water which would otherwise run off, while the cultipacker seeder plants the seed and produces a firm seedbed (fig. 10B). In the absence of competing annual vegetation, on sandy loam soils, some success has been attained from planting lovegrass seed without seedbed preparation. In these cases best results were obtained when the seed was covered by cultipacking.

Most consistent planting success has resulted from placing seed in the ground just prior to the summer rains. However, successful plantings may be made from about June 1 until one week after the summer rains begin, usually about July 10.

Grazing Lehmann lovegrass.--When green and high in moisture content, Lehmann lovegrass is taken well by cattle. Because Lehmann lovegrass grows during the cool temperatures of spring and fall when most native grasses are dormant, this species offers an important supplementary supply of forage. Lehmann lovegrass withstands grazing well, but it should not be used too heavily. Until better utilization guides are developed, cattle should be removed when stubble height averages 3 to 4 inches. It should be emphasized that restoration by range reseeding is only the initial step (fig. 11). Thereafter proper management practices must be carefully observed to maintain the investment in rehabilitation.

SEVEN POINTS OF GOOD RANGE MANAGEMENT

Certain practices that will help obtain better range management can be recommended as the result of studies and observations on the Santa Rita Experimental Range. These are:

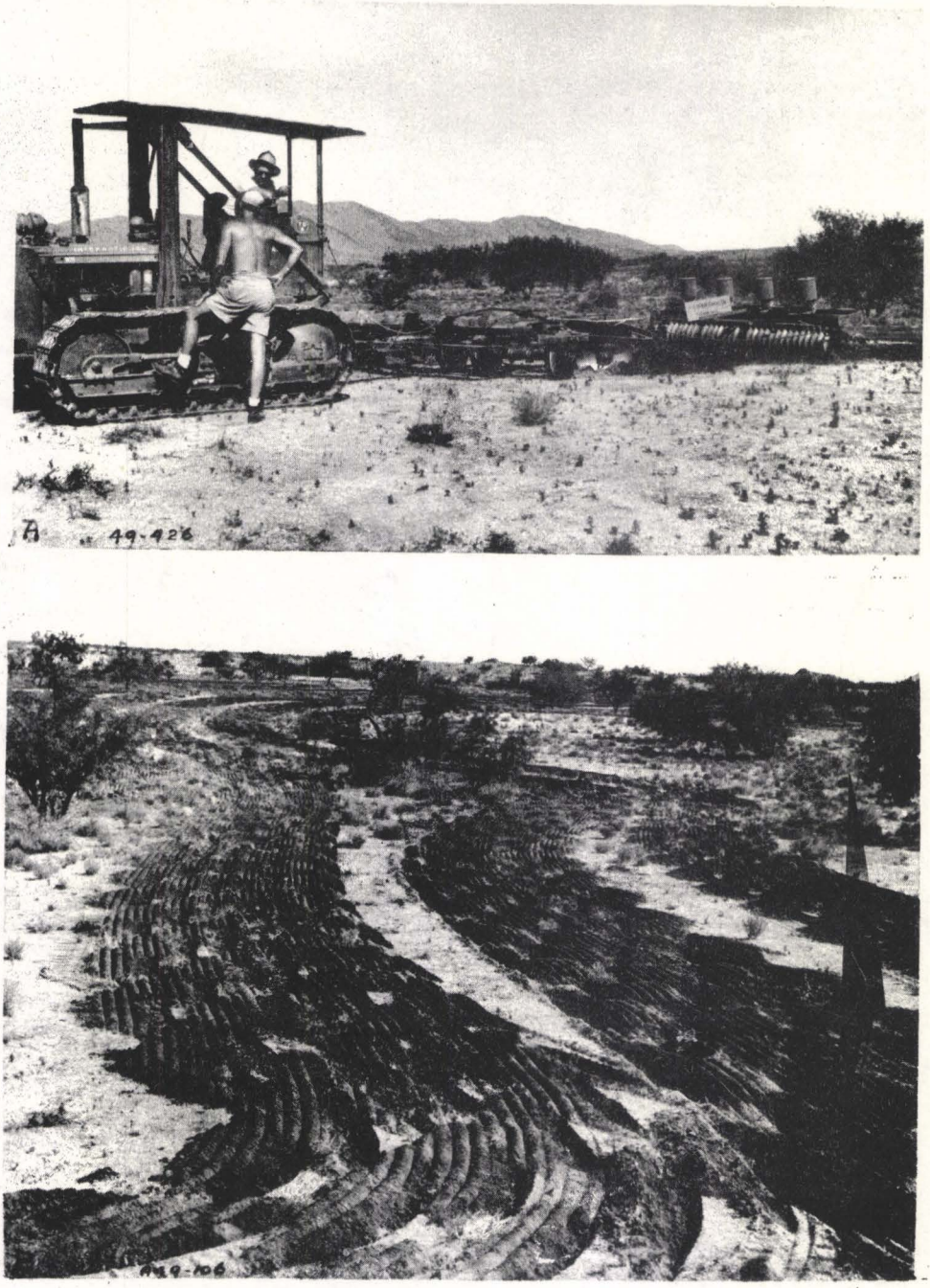
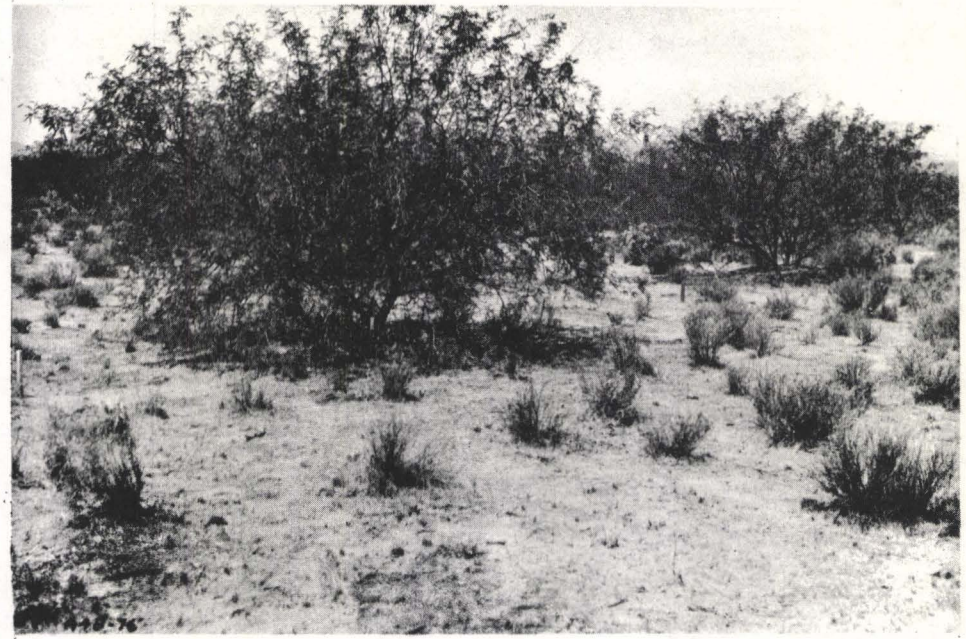


Figure 10.--In many places nature needs help in order to bring the ranges back into productivity. A, Reseeding equipment that can be effectively used in reseeding range areas. A small caterpillar, a V-type eccentric disk, and a cultipacker seeder such as the outfit illustrated can cover many acres per day in reasonably accessible country. B, In this area that has been reseeded note the regularly spaced depressions made by the eccentric disk for the purpose of holding extra water from runoff during the summer rainy period.



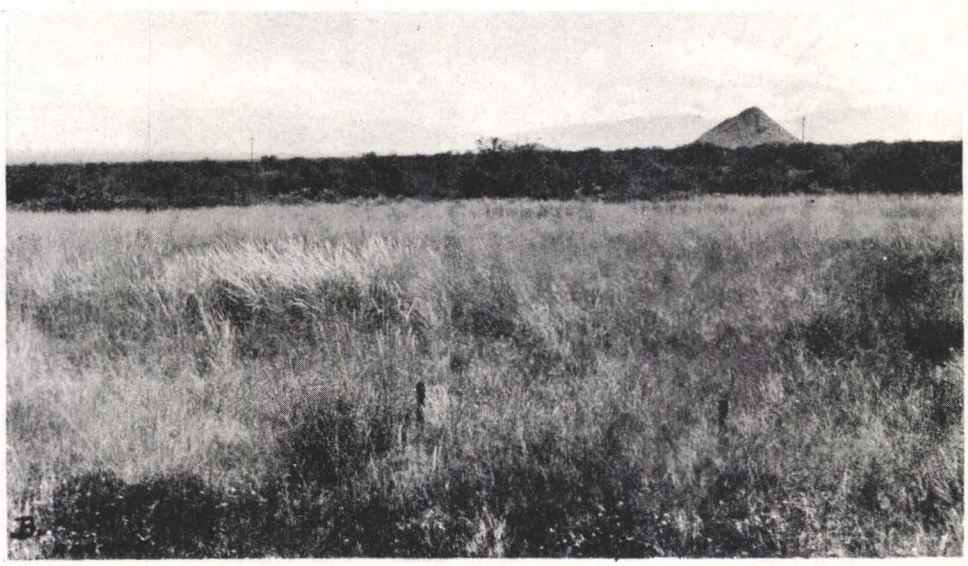


Figure 11.—With a little help from man the range can be brought back. A, A typical area in the semidesert mixed grass type in its natural condition. Perennial grasses have been replaced by a heavy stand of mesquite and other shrubs. B, The same area two years after the mesquite was cleared off and the area reseeded. Lovegrass, tanglehead, and other grasses are now well on their way to rehabilitating the area.

1.--Division of range by fences into breeding herd units of from 50 to 100 head.--Such a practice makes possible (a) better control of cattle with more uniform use of range and less concentration, (b) the application of seasonally controlled grazing as a means of bettering range condition, (c) easier supervision and working of cattle, and (d) higher calf crops by 5 to 10 percent which in large measure help to cover the cost of dividing up the range.

2.--Deferred summer grazing.--Observations have indicated that under deferred and "partially deferred" summer use (a) the better forage grasses are more abundant, (b) the annual yield of forage is higher, (c) the chance for improvement in stand and vigor of forage grasses--in good years following drought--is greatly increased, and (d) green forage is available later in the fall and earlier in the spring.

3.--Adequate distribution of water.--Adequate water is one of the major problems on semidesert ranges. It can usually be developed, however, either with temporary surface tanks or with wells or springs together with pipe lines. Well distributed watering places aid materially in (a) keeping cattle distributed over the range, (b) preventing local overgrazing, and (c) keeping livestock in better condition. The number of cattle at each watering place should not exceed the grazing capacity of the available range within a 1-1/2 to 2 mile radius.

4.--A better understanding of the growth habits and requirements of range forage plants.--The growth of native vegetation too often is taken as a matter of course with little appreciation for the real struggle that semidesert forage plants have to maintain themselves on the range. Full realization of how range forage plants grow, their seeding habits, their response to grazing, and the conditions which encourage abundant herbage production would help measurably in putting range improvement practices into use.

5.--Closer observation of range conditions.--The changes that occur in the condition of a range unit are often so slow that they are more than likely to pass unnoticed. In the absence of some definite measurements or records it is difficult even to compare forage growth of one year with that of another, much less to judge changes that may occur in composition or stand. In occasional instances--such as the past five years of severe drought--the changes become obvious enough to be easily seen, but by then damage is serious. Photographs taken on different parts of the range and repeated at intervals of 2 or 3 years offer perhaps the most feasible means of recording the major changes that are taking place and will furnish a valuable record for the stockman. Supplemental notes and observation of the kinds and amounts of plants growing on the range and the condition of the soil surface will furnish specific information as to trend of range condition.

6.--Care of the range in good years following drought.--The more or less common practice of building up numbers in the first average year that comes along after a drought is probably one of the major factors in continued range deterioration. Experience on the Santa Rita indicates that proper management of the range will do much to counteract the effects of ordinary drought years. However, even the best management cannot prevent some loss in vigor and density of the forage plants in severe drought years on semi-desert ranges. It becomes evident then that the practice of building up numbers in the occasional good years removes the only chance that the range might have to improve. In the drought years the range goes downhill, while in the average or better years it barely manages to hold its own--a gradual process of deterioration.

7.--Plan for range betterment.--A range deteriorated by prolonged drought, misuse, or invasion of worthless shrubs can be brought back to normal production of forage by constant improvement in management accompanied by an action program in range reseeding and noxious plant control on areas where those practices are needed. Don't let a good year stop your plans and action for range improvement.

Additional information on the findings presented in this booklet and other results obtained from research at the Santa Rita Experimental Range are contained in publications available from the Director, Southwestern Forest and Range Experiment Station, Box 951, Tucson, Arizona.

Tucson, Arizona
September 1949
Revised August 1952

APPENDIX

Important Forage Plants on the Santa Rita Experimental Range

Perennial Grasses:

Black grama (Bouteloua eriopoda), a moderately tall, stemmy grass spreading by runners and "sets," has a characteristic silvery pubescence along the lower stems. It is a palatable, long-lived grass most abundant on foothill and upper mesa subtype ranges. It is highly drought resistant. With proper management, which includes light use, or, if possible, complete rest during the summer growing season, it can be maintained in a vigorous productive condition.

Rothrock grama (B. rothrocki), a medium tall, slender bunchgrass has many flag-like spikelets on a single stem. It is palatable but highly susceptible to drought and undependable as a forage species. It is short-lived, but a prolific seed producer.

Sideoats grama (B. curtipendula), a tall, often rather coarse grass, has many small seedheads characteristically arranged along one side of the main stem. It is largely a foothill grass, occurring most abundantly on north slopes. It is fairly drought resistant and withstands moderate grazing. Heavy use results in high mortality, especially of younger plants.

Hairy grama (B. hirsuta), a moderately tall (12 to 24 inches high) grass very similar to blue grama has flag-like spikelets with a "beak" or extension of the flower stem beyond the uppermost flower on each spikelet. Although not abundant in most areas, it is both palatable and drought resistant.

Slender grama (B. filiformis), a short, many-stemmed grass of fine texture, has flowers similar to sprucetop grama except that the skikelets are smooth instead of hairy. Palatable to livestock, it is short-lived and susceptible to drought kill. It occurs in greatest relative abundance on the lower foothill subtype where it may comprise 50 percent or more of the ground cover.

Sprucetop grama (B. chondrosioides), a moderately tall grass (8 to 20 inches in height) with most of its leafage near the ground, has small, hairy, wide-spreading spikelets on a single stem. Occurring principally in the foothill subtype, it is long-lived, palatable, and drought resistant.

Arizona cottongrass (Trichachne californica), a tall (20 to 40 inches in height), fairly coarse bunchgrass, has narrow, conspicuous, cottony seedheads. This palatable species is strongly drought resistand and long-lived. It occurs widely throughout the Experimental Range.

Bush muhly (Muhlenbergia porteri), a stemmy, harsh-appearing, almost wiry grass with finely divided, wide-spreading flower heads, grows to a height of 20 to 40 inches. The stems do not die back, but remain green and continue to elongate in successive seasons. Largely restricted to the lower mesa and semidesert subtypes, it is ordinarily long-lived and drought resistant. This grass is highly palatable but cannot stand prolonged heavy use. Thus, plants growing in the open indicate proper use of the range. If it is found only under the protection of shrubs, heavy use is indicated.

Tanglehead (Heteropogon contortus), is a tall (15 to 36 inches), coarse grass. As the name implies, the seeds have long awns which twist about each other at maturity. Fairly palatable, especially during spring, and drought resistant, it is found on mesa and foothill subtypes. The maximum life span of 7 years under protection is halved under heavy use.

Curlymesquite (Hilaria belangeri), a very low-growing sod grass, spreads by runners. Its small and inconspicuous flowers are commonly infertile. Grazing stimulates lateral spread of the mat-like tufts characteristic of this grass. Although both drought resistant and palatable, it furnishes relatively little forage because its stems are short and the leafage lies close to the ground.

Mesa threeawn (Aristida hamulosa) is a medium-height grass (12 to 24 inches tall) with three divergent awns per seed. Several species of threeawn occur on the Santa Rita. Mesa threeawn takes its name from its usual range, being most common in the mesa subtype. An increase in the abundance of this palatable species generally indicates improvement of ranges in unsatisfactory condition. Many species of threeawn are unpalatable to livestock, and characteristic of deteriorated ranges.

Browse Plants:

Velvet mesquite (Prosopis juliflora var. velutina (Woot.) Sarg.) is a small tree or shrub with pinnately-compound (fern-like) leaves and bean fruits, both of which are relished by cattle. Mesquite has invaded or thickened up on many former grasslands where it has greatly reduced total forage yield and is a serious range pest.

False mesquite (Calliandra eriophylla) is a low-growing shrub which becomes a prostrate plant under heavy grazing. It also has pinnately compound leaves and small bean-like fruits. It is palatable to livestock during all seasons.

Range ratany (Krameria glandulosa) is a low-growing shrub, highly palatable, with narrow gray-green leaves, delicate purplish pink flowers, and bur-like fruits. Though seldom abundant, it is highly regarded as a source of green feed during periods when grasses are dormant.

Wright's eriogonum (Eriogonum wrighti), often called "shrubby buckwheat," is a stemmy, low-growing shrub with woolly gray leaves and grayish to red stems. It is highly palatable but may be killed out by continued heavy use.

Several other minor browse species furnish some forage for livestock.

COOPERATION - UNIVERSITY OF ARIZONA

The University of Arizona and the Arizona Agricultural Experiment Station have cooperated extensively on the Santa Rita Experimental Range since its original establishment as a field station of the Bureau of Plant Industry. This cooperation, which has increased in scope under Forest Service administration of the Santa Rita Experimental Range, has been mutually beneficial.

The University's staff of technicians in the major agricultural fields has been available for consultation. Their diverse laboratory facilities are frequently used by Forest Service technicians. The result has been a more complete appraisal of desert grassland problems than would be possible by the Forest Service alone. Duplication of facilities and personnel has been prevented without impairing the quality of research.

The availability of a controlled experimental range near Tucson has enabled the Arizona Agricultural Experiment Station to carry on many experiments which could not have been conducted without such a study area. Quarters and a laboratory furnished by the Forest Service provide a base for these operations.

A wide variety of problems has been studied, beginning with the first attempts toward sound management of semidesert rangelands. Ecological studies of native plants and animals have provided a basis for sound range management. An intensive study of desert grassland climate was conducted in connection with these experiments.

Experimental feeding of deer and rabbits has provided information on forage preferences of these animals, and the degree to which they compete with domestic livestock.

Along more applied lines, cooperative studies of artificial revegetation and noxious plant control have provided methods for increasing forage production. Many phases of this work were carried on in the laboratories and greenhouses at the University.

The Santa Rita Experimental Range also provides an excellent field laboratory for student use. Range management students are trained here in survey techniques, many of which were developed on the Santa Rita. The extensive use of long-time exclosures and demonstration plots provides excellent "see for yourself" instruction.

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